(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 601 260 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
27.05.1998 Bulletin 1998/22

(51) Int Cl.6: H04M 11/06, H04L 5/14

(21) Application number: 92810978.4

(22) Date of filing: 10.12.1992

(54) **Full-duplex start-up method for modems**

Vollduplex Anlaufverfahren für Modems

Procédé de démarrage à duplex intégral pour modems

(84) Designated Contracting States:
DE FR GB

(43) Date of publication of application:
15.06.1994 Bulletin 1994/24

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- IEEE TRANSACTIONS ON COMMUNICATIONS vol. 38, no. 5, May 1990, NEW YORK US pages 629 - 638 CIOFFI 'A fast echo canceller initialization method for the CCITT V. 32 modem'

EP 0 601 260 B1

Printed by Jouve, 75001 PARIS (FR)

Description

Field of Invention

The present invention concerns a method for the fast start-up of modems for full-duplex data transmission over the Public Switched Telephone Network (PSTN).

Background

A particular type of modems for full-duplex data transmission over the PSTN has been defined in the CCITT Blue Book, published by the CCITT in Geneva, 1989, in Volume VIII, Fasc. VIII.1. The respective Recommendation V.32 is entitled "A family of 2-wire, duplex modems operating at data signalling rates of up to 9600 bit/s for use on the general switched telephone network and on leased telephone-type circuits". In this recommendation, a start-up procedure is described for exchanging signals between a call mode modem and an answer mode modem in order to train the echo cancellers and equalizers of these modems. This procedure is based on sending essential parts of the training signals in a half-duplex manner. The start-up time required for executing this procedure is in the range of 4 to 8 seconds, which is considered too long for many uses. The follow-on Recommentation V.32 bis, published by the CCITT in 1991, describes essentially the same start-up procedure, but allows for higher data rates than V.32.

A method suited for training echo cancellers in full-duplex modems faster than in V.32 modems is described in a publication by J.M. Cioffi: "A Fast Echo Canceller Initialization Method for the CCITT V.32 Modem", IEEE Transactions on Communications, Vol.38, No.5, May 1990, pp.629-638.

Some new aspects of full-duplex modem initialization are presented in a publication by X. Chen at al. entitled "A Full-Duplex Fast Training Algorithm for Simultaneously Estimating Echo and Channel Response", Proceedings SUPERCOMM/ICC '92, Paper 351.1, pp.1503-1507. A technique for simultaneously estimating the responses of near-end and far-end echo paths and the signal path from the remote modem to the local modem is described. These responses are then used to adjust the echo cancellers and the equalizer. The authors propose to send for this purpose known periodic training sequences. One reason for this is the difficulty for the receiving modem to determine the beginning of a non-periodic training sequence sent by the remote modem. This is one of the problems solved by the present invention.

A high speed two wire modem communicating with another modem over a communication media in a Full-duplex mode using a common start-up procedure is further known from EP-A-0 513 527.

Objects of the Invention

The main object of this invention is to provide an initialization procedure for a next generation of modems for the PSTN currently under consideration by CCITT. With the invented start-up procedure the modem initialization can be completed in considerably less time than by presently used procedures. Current generation modems, like V.22 and V. 32 modems, operate only at one given modulation rate. The invented procedure accounts for the automatic selection of a most suitable set of modulation and coding parameters for given telephone channel, which will be an important new requirement for the next generation of modems.

Another object is to improve known fast inizialization procedures with respect to their ability to achieve accurate echo canceller and equalizer adjustments.

The invention, as defined in the Claims, provides from the beginning of the initialization procedure in an overlapped and interleaved manner an exchange of information necessary for evaluating the transmission channel conditions, chosing appropriate transmission parameters. and adjusting receiver settings. It minimizes handshaking delays which have henceforth contributed significantly to the prolongation of start-up delays. When no significant round-trip delay is involved, the new start-up procedure can lead to full-duplex data transmission within one second after the calling modem responds to the answer tone of the called modem. The modems will then transmit data reliably at the modulation rate and center frequency appropriate for the channel, and at an initial bit rate. The maximum achievable bit rate can be achieved later during full-duplex transmission through rate negotiations in any suitable manner which is not subject of the present invention.

The principles of an embodiment of the invention are described in the following with reference to drawings. The drawings show:

Fig. 1 - the start-up procedure for exchanging signals and messages between a calling modem and an answering modem, as provided by the present invention;

Fig. 2 - an example of the spectra of the messages and the channel probing tones exchanged between the modems

during the channel probing and ranging phase in the start-up procedure of Fig.1;

Fig. 3 - an extended version of the start-up procedure of Fig. 1 with additional rate-request messages exchanged between the modems before data transmission.

Introduction

Users of V.32 modems consider the start-up time of 4-8 seconds of these modems often as too long. For a faster modem, the achievement of a considerably shorter start-up time is therefore desirable. In this invention, a start-up procedure is proposed, which in the absence of significant round-trip delay can lead to full-duplex data transmission within one second after the call modem responds to the answer tone. The modems will then transmit data with modulation and coding parameters appropriate for the respective directions of transmission, and at safe initial bit rates. The maximum bit rates for reliable data transmission are to be achieved later through rate negotiations, which are beyond the scope of this invention.

General Function

The proposed full-duplex start-up procedure is illustrated in Figure 1. To obtain a short start-up time, channel probing and ranging operations and training of the echo cancellers and receivers are performed simultaneously by both modems. Handshake operations that introduce round-trip delays are kept to a minimum. It is assumed that the calling modem (CM) is connected-to-line when the answering modem (AM) begins sending the answer tone (ANS). It is further assumed that both modems are of a type that can perform the necessary operations.

During the initial probing and ranging phase, the modems exchange identification messages and determine from two sets of simultaneously transmitted tones the most appropriate modulation and coding parameters for subsequent fullband training and data transmission in each channel direction. The results are exchanged between the modems by response messages in a manner which also allows for measuring round-trip delay. During the subsequent training phase, the modems transmit fullband training sequences with the modulation parameters established in the first phase. Each modem estimates simultaneously the responses of the near-end and far-end signal paths, and the signal path from the remote modem. These responses are then used to adjust the echo cancellers and derive with some further processing the remaining receiver settings. Finally, the modems send data at safe initial rates.

The Probing and Ranging Phase

The calling-modem identification message (CIM) and the answering-modem identification message (AIM) are transmitted in the form of two narrowband modulated signals with center frequencies near midband, as indicated in Figure 2. Scrambled QPSK modulation with a data rate of 800 bit/s is proposed. Alternatively, coded 8-PSK may be employed to increase the robustness of the start-up procedure against noise events. The identification messages (CIM and AIM) consist of repetitively transmitted fixed-length blocks, preferably of 48 bits length, each conveying the following information:

- Supported modulation parameters for transmission and reception, i.e. set of modulation rates, center frequencies, preemphasis functions, transmit-power levels (including an indication whether or not different parameters are allowed for transmission and reception).
- Supported coding parameters for transmission and reception, i.e. types of modulation codes, data rates, capabilities for precoding and warping.
- A block sequence number.
- Framing bits to identify CIM or AIM block boundaries, and parity-check bits for error detection.

As indicated in Figure 1, each modem keeps a local time measured from the beginning of CIM or AIM transmission. By including in the CIM and AIM blocks a sequence number, each modem can establish a relative time of the remote modem, when it first correctly receives a CIM or AIM block.

The calling-modem response message (CRM) and the answering-modem response message (ARM) employ the same modulation as used for the CIM and AIM. The CRM and ARM consist at least of one block, preferably of 48 bits length, conveying the following information:

- Selected modulation and coding parameters for subsequent transmission of a training sequence and then data from the remote modem, i.e. modulation rate, center frequency, modulation code, precoding function, preemphasis function, use of warping, transmit power, and initial bit rate.
- Measured frequency shift of signals received from the remote modem.
- The relative time of the remote modem, when transmission of a CRM or ARM block begins.
- Framing bits to identify CRM or ARM block boundaries, and parity-check bits for error detection.

Simultaneously with the modulated narrowband signals, two sets of interleaved tones are transmitted in each channel direction for channel probing, as indicated in Figure 2. It is proposed to place the CM tones at frequencies 62.5 + k×100 Hz, and the AM tones at frequencies 12.5+k×100 Hz. If the transmission channels contain elements, which introduce spectral aliasing around a frequency that is a multiple of 100 Hz, e.g., 3200 Hz, then the alias CM and AM tones occur at 37.5+m×100 Hz and 87.5 + m×100 Hz, respectively. Thus, they do not interfere with the original CM and AM tones.

By analysing the received CM and AM tones, the modems determine the useful bandwidth for full-duplex transmission in both channel directions. In addition, the spectral shape of these channel in the critical bandedge regions and spectral signal-to-noise ratios are estimated. To measure harmonic distortion, one tone in each set of tones can be omitted (not shown in Figure 2). It may also be possible to estimate harmonic distortion from the errors signals associated with the received CIM or AIM symbols.

The probing and ranging operations are now described in detail.

1. The CM is initially conditioned to detect ANS. When ANS is detected, the CM waits for 0.5 to 1.0 second, according to V.25, to cause disabling of echo suppressors and/or cancellers in the network.

2. Then the CM begins sending CIM blocks and CM tones, and waits for detection of AIM signals or AM tones. Attention is now focussed on the AM. The further operations performed by the CM are similar to those of the AM.

3. While sending ANS, the AM is conditioned to detect reception of CIM signals or CM tones. When this occurs, the AM ceases to send ANS and begins sending AIM blocks and AM tones.

4. When the AM first correctly receives a CIM block, it stores the modulation and coding parameters supported by the CM and establishes from the sequence number in this block the relative CM time. The AM knows, of course, its own supported modulation and coding parameters, and its local AM time.

5. The AM analyses the CM tones to determine appropriate modulation and coding parameters for subsequent fullband transmission from the CM to the AM. The time taken for this analysis is determined only by the AM. Among the modulation and coding parameters commonly supported by both modems, the AM eventually choses one particular parameter set and encodes these parameters in an ARM block, together with the measured frequency shift of the signals received from the CM.

6. The AM then starts sending ARM blocks. At least in the first ARM block, the AM includes the relative CM time perceived by the AM, when it start to transmit this block.

7. The AM stops sending ARM blocks, if it has sent at least one complete ARM block and has received at least one complete CRM block. (In Figure 1, the AM sends two complete ARM blocks and stops sending a third ARM block, when the first complete CRM block is received. The CM sends only one complete CRM block and then stops sending the second CRM block, when it receives the first ARM block.)

8. The AM now knows the modulation and coding parameters for subsequent fullband transmission to the CM. The AM computes round-trip delay (RTD) from the difference between the local AM time, when it receives the CRM block, and the relative AM time contained in the received CRM block. For this calculation modem internal propagation and processing delays must also be taken into account.

Echo-Canceller and Receiver Training Phase

The calling-modem training sequence (CTRN) and answering-modem training sequence (ATRN) consist of pseudo

random symbols transmitted with the modulation parameters indicated to the CM in the ARM, and to the AM in the CRM. Preemphasis, if requested, is used, but precoding, if also requested, is disabled. The training symbols are chosen from a sufficiently large signal constellation comparable in shape and power to the constellation used for subsequent data transmission, but usually with fewer symbols. The training symbols are generated by a scrambler. At the beginning of sending the training sequence, the scrambler is initialized to the state that would have been reached, if training symbols would already have been generated since the beginning of local modem time at the chosen modulation rate with a known intitial scrambler state. Since the remote modem knows the relative time of the modem sending the training sequence, it can perform a similar initialization of its scrambler for local reference symbol generation, when the need for knowing the training symbols arises. (There exist also other methods to associate knowledge of time with knowledge of pseudo random training symbols. For example, time can first be expressed in units of modulation intervals and then mapped by a suitable function into symbol indices, in a manner similar to encryption.)

Again, the operations performed by the CM and AM are similar. The following description is given for the CM.

1. After stopping sending CRM, the CM waits for a short guard interval. Then the CM starts sending the CTRN with the scrambler initialized according to local CM time as described above.

2. After one round-trip delay (RTDO, the CM continues to send the CTRN for a fixd period of time. During this time, the CM receives a stationary composte signal consisting of three signals: near-end echo, far-end echo, and the signal received from the AM. These component signals are caused by the known CTRN symbols without and with RTD, and the ATRN symbols which can locally be regenerated as described above. From the frequency-shift measurements exchanged between the modems, the CM knows also the frequency shifts of the ATRN signals and the far-end echo.

3. The CM has to determine jointly the responses of the near-end and far-end echo paths and the signal path from the AM to the CM. These responses can be obtained by known fast channel-estimation algorithms within a time period, which is a small multiple of the sum of the time spans of the three responses.

4. The estimated responses of the echo paths are then used to adjust the near-end and far-end echo cancellers. Some further processing is needed to determine the remaining receiver settings, e.g. the coefficients of a linear equalizer, in the simplest case. The CM can now decode further received training symbols.

5. The CM transmits an ending delimiter (ED). The ED consists of a distinctive pattern of training symbols, e.g., sign-inverted symbols of the continued CTRN, that mark the end of transmission of symbols from the constellation of training symbols. Thereafter, the CM starts sending scrambled data using the full set of modulation and coding parameters received earlier from the AM. First, a block of scrambled all-one bits (B) is transmitted. Then user data are transmitted.

6. After receiving a similar ED from the AM, the CM conditions its receiver to decode scrambled data according to the full set of modulation and coding parameters, which the CM has sent earlier to the AM. When a sufficient number of scrambled all-one bits has been received, the receiver starts to output decoded user bits.

This completes the description of the essential concepts of the start-up procedure.

Estimate of Start-Up Time

Given below are approximate numbers for the time from the beginning of CIM transmission to the beginning of data transmission by the CM.

1.	Start of CIM to detection of AIM	130 ms + RTD
2.	Receive AIM, analyse AM tones (5 blocks @ 48 bits at 800 bit/s)	300 ms
3.	Send CRM (1 block @ 48 bits at 800 bit/s)	60 ms
4.	Send CTRN and perform full-duplex training (RTD + 512 T at 3000 Baud)	171 ms + RTD
5.	Send ED and B (8+64 T at 3000 Baud)	24 ms
	Total from start of CIM to sending DATA for the CM	685 ms + 2 RTD

Rate Requests

In the proposed start-up procedure so far described, the initial bit rates for data transmission by the CM and the AM are already determined during the probing and ranging phase and communicated to these modems in the ARM and CRM blocks, respectively. It may be advantageous to decide on these rates at the end of the training phase, at the expense of prolonging the start-up time by at least one RTD. Figure 3 illustrates the sending of rate requests (R). The R expresses the bit rate that a modem decides to be appropriate for reception when it has evaluted the quality of signal reception during reception of further symbols from the training-symbol constellation. The other modem will respond with ED, when it has received R and also sent a corresponding R.

The use of rate requests may be further extended to require from the remote modem a particular use of precoding and warping, and/or a change in transmit power. The ED may be expanded to indicate and thereby confirm explicity some of the modulation and coding parameters that will be used for subsequent data transmission.

Claims

1. A method of starting full-duplex communication between a first station with a calling modem (CM) and a second station with an answering modem (AM), the answering modem, when called, sending an answering tone (ANS) to the calling modem (CM), the method comprising the following steps:

    a1. sending from each of the modems to the other one, in an interleaved and overlapping manner:

        a set of channel probing tones (CM and AM tones) at predetermined frequencies, and

        repetitive identification messages (CIM, AIM) in a given frequency range, containing the sending modem's local time (local CM time, local AM time) when the message is sent, and characterizing the sending modem by its capabilities in terms of parameters including supported modulation rates, center frequencies, and supported coding;

    a2. at the respective other modem receiving said probing tones and identification messages:

        establishing a running time reference (relative CM or AM time, respectively) from the remote modem's local time (local CM or AM time, respectively) received in said identification message(s), and

        determining transmission channel characteristics, in particular a useful bandwidth (UB), from said received probing tones;

    b1. sending from the respective other modem:
    repetitive response messages (CRM, ARM), each containing the relative time (relative CM or AM time, respectively) at this other modem and transmission parameters selected from the parameters supported by both modems, based on the determined channel characteristics, in particular the modulation rate and center frequency, for subsequent transmission of training and data signals from the modem receiving said particular response message;

    b2. at the modem receiving said response message (CRM, ARM):

        determining the round trip delay (RTD) by comparing the received relative time and the actual local time at the receiving modem;

        extracting the information on the transmission parameters to be used for subsequent transmission of training and data signals to the modem sending said response message;

    c1. sending from each modem, at the respective determined modulation and coding parameters, full-band training sequences (CTRN, ATRN);

    c2. determining, at each modem that now sends and receives training sequences (CTRN, ATRN), the responses of the respective detected near-end and far-end echo paths and of the signal paths from the remote modem to adjust receiver settings, in particular echo cancellors and equalizers as necessary for subsequent data

transmission.

2. The method of claim 1, wherein

the calling modem (CM), after detecting the answering tone (ANS), waits for a predetermined time and then sends the calling modem identification message (CIM) in a first frequency range and the channel probing tones (CM tones) at given frequencies of a first set,

correspondingly, when the answering modem (AM), which is conditioned to receive said calling modem identification message (CIM), detects the latter, it stops sending said answering tone (ANS) and starts transmitting the answering modem identification message (AIM) in a second frequency range and the respective channel probing tones (AM tones) at given frequencies of a second set.

3. The method of claim 1 or 2, wherein

said identification messages (CIM, AIM) consist of repetitively transmitted blocks conveying at least information on:

modulation rates, center frequencies, and data rates, at which the modem sending said identification message (CIM, AIM) can operate,

elapsed time (local CM or AM time, respectively) since beginning of said identification message (CIM, AIM) transmission, allowing the respective modem (CM or AM) to establish a time reference (relative AM or CM time, respectively),

block boundaries and error detection.

4. The method of any preceding claim, wherein

the answering modem (AM) recognizes from at least one of said calling modem identification messages (CIM) the capabilities of the calling modem (CM), establishes the calling modem reference time (relative CM time), and analyzes the calling modem channel probing tones (CM tones) to determine appropriate modulation and coding parameters for transmission from the calling modem (CM) to the answering modem (AM),

correspondingly, the calling modem (CM) recognizes from at least one of said answering modem identification messages (AIM) the capabilities of the answering modem (AM), establishes the answering modem reference time (relative AM time), and analyzes the answering modem channel probing tones (AM tones) to determine appropriate modulation and coding parameters for transmission from the answering modem (AM) to the calling modem (CM),

each modem stops sending identification messages (CIM, AIM) and starts transmitting response messages (ARM, CRM) upon

- successful reception of an identification message (CIM, AIM) from the other modem, and
- completed analysis of the channel characteristics,

and, finally, each modem stops transmitting response messages (ARM, CRM) upon

- transmission of at least one complete response message, and
- successful reception of at least one response message.

5. The method of claim 1 or 4, wherein

the response messages (ARM, CRM) consist of repetitively transmitted blocks conveying at least information on:

selected modulation and coding parameters for subsequent transmissions, in particular modulation rate, center frequency, transmit power, type of coding, and initial bit rate,

the sending modem reference time (relative AM or CM time), when such sending modem response message block is transmitted, to be used to determine round-trip delay (RTD),

block boundaries and error detection.

6. The method of claim 1 or 5, wherein, subsequent to the response message (CRM, ARM),

each modem (CM or AM) transmits the training sequence (CTRN or ATRN) for the duration of the determined round-trip delay (RTD) plus a fixed time period,

each modem determines, as necessary, channel responses, and receiver settings from the received stationary composite signal comprising near-end echo, far-end echo, and the training sequence (ATRN or CTRN) from the remote modem, and

each modem is then ready for transmitting an ending delimiter (ED) indicating the end of transmission of training signals to the remote modem and conditioned to receive such a delimiter (ED) from the remote modem.

7. The method of claim 1, wherein the identification messages (CIM and AIM) and/or the response messages (CRM and ARM) are transmitted in form of a narrow-band modulated signal with a center frequency near mid-band of the transmission channel bandwidth, in particular with differing mid-frequencies.

8. The method of any preceding claim, wherein the identification message (CIM or AIM) has a block length of about 32 bits or more.

9. The method of any preceding claim, wherein the frequencies of the channel probing tone sets (AM and CM tones) are selected outside the frequency range of the identification messages, in particular towards both ends of the transmission channel bandwidth.

10. The method of claim 9, wherein one set of probing tones is placed at frequencies of 12.5+k×100 Hz and the other set at 62.5+k×100 Hz, k being the ordinal number of the respective probing tone.

11. The method of any preceding claim, wherein the training signals (ATRN or CTRN) consist of a sequence of pseudo-random modulation symbols uniquely associated with time, preferably generated by a scrambler which is initialized at the start of the sending modem's first identification message (CIM or AIM), such that the receiving modem can identify the transmitted modulation symbols by referring to the sending modem's reference time at the receiving modem (relative AM or CM time), as communicated in the identification message (CIM or AIM).

12. The method of claim 11, wherein the modulation parameters of the training sequences (CTRN, ATRN) are uniquely determined by the information contained in the response messages (CRM, ARM).

Patentansprüche

1. Ein Verfahren zum Starten der Vollduplex-Kommunikation zwischen einer ersten Station mit einem anrufenden Modem (CM) und einer zweiten Station mit einem antwortenden Modem (AM), wobei das antwortende Modem einen Antwortton (ANS) an das anrufende Modem (CM) sendet, wenn es angerufen wird, und wobei das Verfahren die folgenden Schritte umfaßt:

a1. Verschachteltes und überlappendes Senden von jedem der Modems an das andere Modem:

eine Gruppe von Kanalabtasttönen (CM- und AM-Tönen) mit vorbestimmten Frequenzen, und

periodische Identifikationsmeldungen (CIM, AIM) in einem bestimmten Frequenzbereich, die die Ortszeit des sendenden Modems (CM-Ortszeit, AM-Ortszeit) enthalten, wenn die Meldung gesendet wird, und die das sendende Modem durch seine Leistungsmerkmale im Hinblick auf Parameter wie z.B. unterstützte Modulationsraten, Schwerpunktfrequenzen und unterstützte Codierung kennzeichnen;

a2. Am betreffenden anderen Modem, das die Abtasttöne und Identifikationsmeldungen empfängt:

Festsetzen eines Laufzeitbezugspunkts (relative CM- bzw. AM-Zeit) aus der Ortszeit des fernen Modems (CM- bzw. AM-Ortszeit), die mit der (den) Identifikationsmeldung(en) empfangen wird, und Bestimmen der Übertragungskanaleigenschaften, insbesondere einer Nutzbandbreite (UB) aus den empfangenen Abtasttönen;

b1. Senden vom jeweils anderen Modem:
Periodische Antwortmeldungen (CRM, ARM), die jeweils die relative Zeit (relative CM- bzw. AM-Zeit) an diesem anderen Modem und Übertragungsparameter enthalten, die aus den von beiden Modems unterstützten Parametern auf Basis der ermittelten Kanaleigenschaften ausgewählt wurden, insbesondere die Modulationsrate und Schwerpunktfrequenz, zur nachfolgenden Übertragung von Trainings- und Datensignalen vom Modem, das die betreffende Antwortmeldung empfängt;

b2. Am Modem, das die Antwortmeldung (CRM, ARM) empfängt:

Bestimmen der Umlaufverzögerung (RTD) durch Vergleichen der empfangenen Relativzeit und der tatsächlichen Ortszeit am empfangenden Modem;

Extrahieren der Informationen über die Übertragungsparameter, die für die nachfolgende Übertragung von Trainings- und Datensignalen an das Modem, das die Antwortmeldung sendet, verwendet werden sollen;

c1. Senden von Vollband-Trainingssequenzen (CTRN, ATRN) von jedem Modem mit den jeweils ermittelten Modulations- und Codierparametern;

c2. An jedem Modem, das nun Trainingssequenzen (CTRN, ATRN) sendet und empfängt, Bestimmen der Antworten der jeweils ermittelten Nah- und Fernechopfade und der Signalpfade vom fernen Modem, um die Empfängereinstellungen, insbesondere Echokompensatoren und Entzerrer, für die nachfolgende Datenübertragung nach Bedarf anzupassen.

2. Das Verfahren gemäß Anspruch 1, bei dem

das anrufende Modem (CM) nach Entdeckung des Antworttons (ANS) während einer vorbestimmten Zeit wartet und dann die Identifikationsmeldung (CIM) des anrufenden Modems in einem ersten Frequenzbereich und die Kanalabtasttöne (CM-Töne) mit bestimmten Frequenzen einer ersten Gruppe sendet,

in entsprechender Weise, wenn das antwortende Modem (AM), das auf den Empfang der Identifikationsmeldung des anrufenden Modems (CIM) ausgerichtet ist, das Modem bei Entdecken dieser Meldung das Senden des Antworttons (ANS) stoppt und mit der übertragung der Identifikationsmeldung (AIM) des antwortenden Modems in einem zweiten Frequenzbereich und der entsprechenden Kanalabtasttöne (AM-Töne) mit bestimmten Frequenzen einer zweiten Gruppe beginnt.

3. Das Verfahren gemäß Anspruch 1 oder 2, bei dem

die Identifikationsmeldungen (CIM, AIM) aus periodisch übertragenen Blöcken bestehen, die mindestens folgende Informationen bereitstellen:

Modulationsraten, Schwerpunktfrequenzen und Datenraten, bei denen das Modem, das die Identifikationsmeldungen (CIM, AIM) sendet, betrieben werden kann,

abgelaufene Zeit (CM- oder AM-Ortszeit) seit Übertragungsbeginn der Identifikationsmeldung (CIM, AIM), das dem jeweiligen Modem (CM oder AM) die Festsetzung einer Bezugszeit (relative AM- bzw. CM-Zeit) ermöglicht,

Blockgrenzen und Fehlererkennung.

4. Das Verfahren gemäß einem der vorhergehenden Ansprüche, bei dem

das antwortende Modem (AM) aus mindestens einer der Identifikationsmeldungen des anrufenden Modems (CIM) die Leistungsmerkmale des anrufenden Modems (CM) erkennt, die Bezugszeit des anrufenden Modems

festsetzt (relative CM-Zeit) und die Kanalabtasttöne (CM-Töne) des anrufenden Modems analysiert, um die geeigneten Modulations- und Codierparameter für die Übertragung vom anrufenden Modem (CM) zum antwortenden Modem (AM) zu bestimmen,

in entsprechender Weise das anrufende Modem (CM) aus mindestens einer der Identifikationsmeldungen des antwortenden Modems (AIM) die Leistungsmerkmale des antwortenden Modems (AM) erkennt, die Bezugszeit des antwortenden Modems (relative AM-Zeit) festsetzt und die Kanalabtasttöne des antwortenden Modems (AM-Töne) analysiert, um geeignete Modulations- und Codierparameter für die übertragung vom antwortenden Modem (AM) zum anrufenden Modem (CM) zu bestimmen,

jedes Modem das Senden von Identifikationsmeldungen (CIM, AIM) stoppt und mit der Übertragung von Antwortmeldungen (ARM, CRM) beginnt, und zwar nach

- erfolgreichem Empfang einer Identifikationsmeldung (CIM, AIM) vom anderen Modem
- abgeschlossener Analyse der Kanaleigenschaften,

und schließlich jedes Modem die Übertragung von Antwortmeldungen (ARM, CRM) stoppt, und zwar nach

- Übertragung von mindestens einer vollständigen Antwortmeldung, und
- erfolgreichem Empfang von mindestens einer Antwortmeldung.

5. Das Verfahren gemäß Anspruch 1 oder 4, bei dem

die Antwortmeldungen (ARM, CRM) aus periodisch übertragenen Blöcken bestehen, die mindestens folgende Informationen enthalten:

ausgewählte Modulations- und Codierparameter für nachfolgende Übertragungen, insbesondere Modulationsrate, Schwerpunktfrequenz, Sendeleistung, Codierart und anfängliche Bitrate,

die Bezugszeit des sendenden Modems (relative AM- oder CM-Zeit), wenn ein solcher Antwortmeldungsblock des sendenden Modems übertragen wird, die zur Bestimmung der Umlaufverzögerung (RTD) verwendet wird,

Blockgrenzen und Fehlererkennung.

6. Das Verfahren gemäß Anspruch 1 oder 5, bei dem im Anschluß an die Antwortmeldung (CRM, ARM)

jedes Modem (CM oder AM) die Trainingssequenz (CTRN oder ATRN) während der Dauer der ermittelten Umlaufverzögerung (RTD) zuzüglich einer festen Zeitperiode überträgt,

jedes Modem nach Bedarf die Kanalantworten und Empfängereinstellungen aus dem empfangenen stationären Signalgemisch bestimmt, welches das Nahecho, Fernecho und die Trainingssequenz (ATRN oder CTRN) des fernen Modems umfaßt, und

jedes Modem dann für die Übertragung eines Endbegrenzers (ED) bereit ist, der das Ende der Übertragung von Trainingssignalen an das ferne Modem signalisiert, und so konditioniert ist, daß es einen solchen Begrenzer (ED) vom fernen Modem empfängt.

7. Das Verfahren gemäß Anspruch 1, bei dem die Identifikationsmeldungen (CIM und AIM) und/oder die Antwortmeldungen (CRM und ARM) in Form eines modulierten Schmalbandsignals mit einer Schwerpunkt frequenz nahe der Bandmitte der Übertragungskanalbandbreite, insbesondere mit unterschiedlichen Mittenfrequenzen, übertragen werden.

8. Das Verfahren gemäß einem der vorhergehenden Ansprüche, bei dem die Identifikationsmeldung (CIM oder AIM) eine Blocklänge von rund 32 Bits oder mehr aufweist.

9. Das Verfahren gemäß einem der vorhergehenden Ansprüche, bei dem die Frequenzen der Kanalabtasttongruppen

(AM-und CM-Töne) außerhalb des Frequenzbereichs der Identifikationsmeldungen gewählt werden, insbesondere in Richtung auf beide Enden der Übertragungskanalbandbreite.

10. Das Verfahren gemäß Anspruch 9, bei dem eine Gruppe von Abtasttönen auf Frequenzen von 12,5+kx100Hz und die andere Gruppe auf 62,5+kx100Hz gelegt wird, wobei k die Ordnungszahl des entsprechenden Abtasttons ist.

11. Das Verfahren gemäß einem der vorhergehenden Ansprüche, bei dem die Trainingssignale (ATRN oder CTRN) aus einer Folge von pseudozufälligen Modulationssymbolen bestehen, die in eindeutiger Weise auf die Zeit bezogen sind und vorzugsweise von einem Verwürfler erzeugt werden, der zu Beginn der ersten Identifikationsmeldung des sendenden Modems (CIM oder AIM) initialisiert wird, damit das empfangende Modem die übertragenen Modulationssymbole durch Bezugnahme auf die Bezugszeit des sendenden Modems, so wie sie in der Identifikationsmeldung (CIM oder AIM) übermittelt wird, am empfangenden Modem (relative AM- oder CM-Zeit) identifizieren kann.

12. Das Verfahren gemäß Anspruch 11, bei dem die Modulationsparameter der Trainingssequenzen (CTRN, ATRN) in eindeutiger Weise durch die Informationen bestimmt werden, die in den Antwortmeldungen enthalten sind (CRM, ARM).

Revendications

1. Un procédé de démarrage à duplex intégral d'une communication entre un premier poste, ayant un modem appelant (CM) et un deuxième poste ayant un modem répondant (AM), le modem répondant, une fois appelé, envoyant une tonalité de réponse (ANS) au modem appelant (CM), le procédé comprenant les étapes ci-après :

   a1. envoi, depuis chacun des modems à l'autre, d'une manière imbriquée et chevauchée :

      d'un jeu de tonalités d'échantillonnage de canal (tonalités CM et AM) à des fréquences prédéterminées, et

      de messages d'identification répétitifs (CIM, AIM) dans une plage de fréquences donnée, contenant le temps local du modem émetteur (temps CM local, temps AM local), lorsque le message est envoyé, et caractérisant le modem émetteur par ses capacités en termes de paramètres y compris les rapidités de modulation supportés, les fréquences nominales supportées et le codage supporté;

   a2. à l'autre modem respectif, recevant lesdites tonalités d'échantillonnage et les messages d'identification :

      établissement d'une référence de temps de service (temps CM ou AM relatif, respectivement) à partir du temps local du modem distant (temps CM ou AM local, respectivement) reçu dans le ou lesdits message (s) d'identification, le ou lesdits message(s) d'identification, et

      détermination des caractéristiques du canal de transmission, en particulier de la largeur de bande utile (UB), à partir desdites tonalités d'échantillonnage reçues;

   b1. envoi, depuis l'autre modem respectif :
   de messages de réponse répétitifs (CRM, ARM), contenant chacun le temps relatif (temps CM ou AM relatif, respectivement) à cet autre modem, et des paramètres de transmission sélectionnés parmi les paramètres supportés par les deux modems, en se basant sur les caractéristiques de canal souhaitées, en particulier la rapidité de modulation et la fréquence nominale, pour une transmission subséquente de signaux de conditionnement et de données, depuis le modem recevant ledit message de réponse particulier;

   b2. au modem recevant ledit message de réponse (CRM, ARM) :

      détermination du temps de propagation aller et retour (RTD) par comparaison entre le temps relatif reçu et le temps local réel au modem recevant;

      extraction de l'information concernant les paramètres de transmission à utiliser pour la transmission subséquente des signaux de conditionnement et de données au modem envoyant ledit message de réponse;

c1. envoi depuis chaque modem, avec les paramètres de modulation et de codage déterminés respectifs, de séquences de conditionnement de pleine bande (CTRN, ATRN);

c2. détermination, à chaque modem qui envoie et reçoit à présent des séquences de conditionnement (CTRN, ATRN), des réponses des trajets d'écho de paradiaphonie et de télédiaphonie détectés respectifs et des trajets de signal venant du modem distant, afin d'ajuster les réglages récepteur, en particulier les suppresseurs d'écho et les égaliseurs, en tant que de besoin, pour la transmission de données subséquente.

2. Le procédé selon la revendication 1, dans lequel

le modèle appelant (CM), après avoir détecté la tonalité de réponse (ANS), attend pendant une durée prédéterminée, puis envoie le message d'identification de modem appelant (CIM) dans une première plage de fréquences et les tonalités d'échantillonnage de canal (tonalités CM) à des fréquences données, d'un premier jeu,

de manière correspondante, lorsque le modem répondant (AM), qui est conditionné pour recevoir ledit message d'identification de modem appelant (CIM), détecte ce dernier, il stoppe l'envoi de ladite tonalité de réponse (ANS) et commence la transmission du message d'identification de modem répondant (AIM), dans une deuxième plage de fréquences, et des tonalités d'échantillonnage de canal respectifs (tonalités AM) à des fréquences données, d'un deuxième jeu.

3. Le procédé selon la revendication 1 ou 2, dans lequel lesdits messages d'identification (CIM, AIM) sont constitués de blocs transmis répétitivement, véhiculant au moins de l'information concernant :

les rapidités de modulation, les fréquences nominales et les taux de données, auxquels le modem émettant ledit message d'identification (CIM, AIM) peut fonctionner,

le temps écoulé (temps CM ou AM local, respectivement) depuis le début de ladite transmission de message d'identification (CIM, AIM), permettant au modem respectif (CM ou AM) d'établir une référence de temps (temps AM ou CM relatif, respectivement),

des limites de blocs et une détection d'erreur.

4. Le procédé selon l'une quelconque des revendications précédentes, dans lequel :

le modem répondant (AM) identifie, à partir d'au moins l'un desdits messages d'identification de modem appelant (CIM), les possibilités du modem appelant (CM), établit le plan de référence de modem appelant (temps CM relatif), et analyse les tonalités d'échantillonnage de canal de modem appelant (tonalités CM), afin de déterminer les paramètres appropriés de modulation et de codage pour la transmission depuis le modem appelant (CM) au modem répondant (AM),

de manière correspondante, le modem appelant (CM) identifie, à partir d'au moins l'un desdits messages d'identification de modem répondant (AIM), les possibilités du modem répondant (AM), établit le temps de référence de modem répondant (temps AM relatif) et analyse les tonalités d'échantillonnage de canal modem répondant (tonalités AM), afin de déterminer des paramètres appropriés de modulation et de codage pour la transmission depuis le modem répondant (AM) vers le modem appelant (CM),

chaque modem cesse l'envoi des messages d'identification (CIM, AIM) et commence la transmission des messages de réponse (ARM, CRM) lors de

- la réception couronnée de succès d'un message d'identification (CIM, AIM) venant de l'autre modem, et
- l'achèvement de l'analyse des caractéristiques de canal,

et, enfin, chaque modem cesse la transmission des messages de réponse (ARM, CRM) lors de

- la transmission d'au moins un message de réponse complet, et
- la réception couronnée de succès d'au moins un message de réponse

5. Le procédé selon la revendication 1 ou 4, dans lequel :

les messages de réponse (ARM, CRM) sont constitués de blocs transmis répétitivement, véhiculant au moins une information concernant :

les paramètres sélectionnés de modulation et de codage pour les transmissions subséquentes, en particulier la vitesse de modulation, la fréquence nominale, la puissance de transmission, le type de codage et le taux binaire initial,

le temps de référence de modem émettant (temps AM ou CM relatif), lorsque ce bloc de message de réponse modem émettant est transmis, devant être utilisé pour déterminer le temps de propagation à l'aller et au retour (RTD),

les limites de blocs et la détection d'erreur.

6. Le procédé selon la revendication 1 ou 5, dans lequel, subséquemment au message de réponse (CRM, ARM),

chaque modem (CM ou AM) transmet la séquence de conditionnement (CTRN ou ATRN) pendant la durée du temps de propagation aller et retour (RTD) déterminé, plus une période de temps fixée,

chaque modem détermine, en tant que de besoin, les réponses de canal et les réglages récepteur à partir du signal composite stationnaire reçu comprenant l'écho de paradiaphonie, l'écho de télédiaphonie et la séquence de conditionnement (ATRN ou CTRN) venant du modem distant, et

chaque modem est ensuite prêt à transmettre un délimiteur de fin de trame (ED) indiquant la fin de transmission des signaux de conditionnement destinés au modem distant et est conditionné pour recevoir un tel délimiteur (ED) depuis le modem distant.

7. Le procédé selon la revendication 1, dans lequel les messages d'identification (CIM et AIM) et/ou les messages de réponse (CRM et ARM) sont transmis sous la forme d'un signal modulé à bande étroite, ayant une fréquence nominale proche du milieu de bande de la largeur de bande de canal de transmission, en particulier lorsque les fréquences médianes sont différentes.

8. Le procédé selon l'une quelconque des revendications précédentes, dans lequel le message d'identification (CIM ou AIM) a une longueur de bloc d'environ 32 bits ou plus.

9. Le procédé selon l'une quelconque des revendications précédentes, dans lequel les fréquences des jeux de tonalités d'échantillonnage de canal (tonalités AM et CM) sont sélectionnées hors de la plage de fréquences des messages d'identification, en particulier vers les deux extrémités de la largeur de canal de transmission.

10. Le procédé selon la revendication 9, dans lequel un jeu de tonalité d'échantillonnage est placé aux fréquences de 12,5 + k x 100 Hz et l'autre jeu à 62,5 + k x 100 Hz, k étant le nombre ordinal de la tonalité d'échantillonnage respective.

11. Le procédé selon l'une quelconque des revendications précédentes, dans lequel les signaux de conditionnement (ATRN ou CTRN) sont constitués d'une séquence de symboles de modulation pseudo-aléatoire, associés de façon unique, au temps, de préférence générés par un brouilleur initialisé au début de l'envoi du premier message d'identification de modem (CIM ou AIM), de manière que le modem recevant puisse identifier les symboles de modulation transmis en se référant au temps de référence du modem émettant, au modem recevant (temps AM ou CM relatif), tel que communiqué dans le message d'identification (CIM ou AIM).

12. Le procédé selon la revendication 11, dans lequel les paramètres de modulation des séquences de conditionnement (CTRN, ATRN) sont uniquement déterminés par l'information contenue dans les messages de réponse (CRM, ARM).

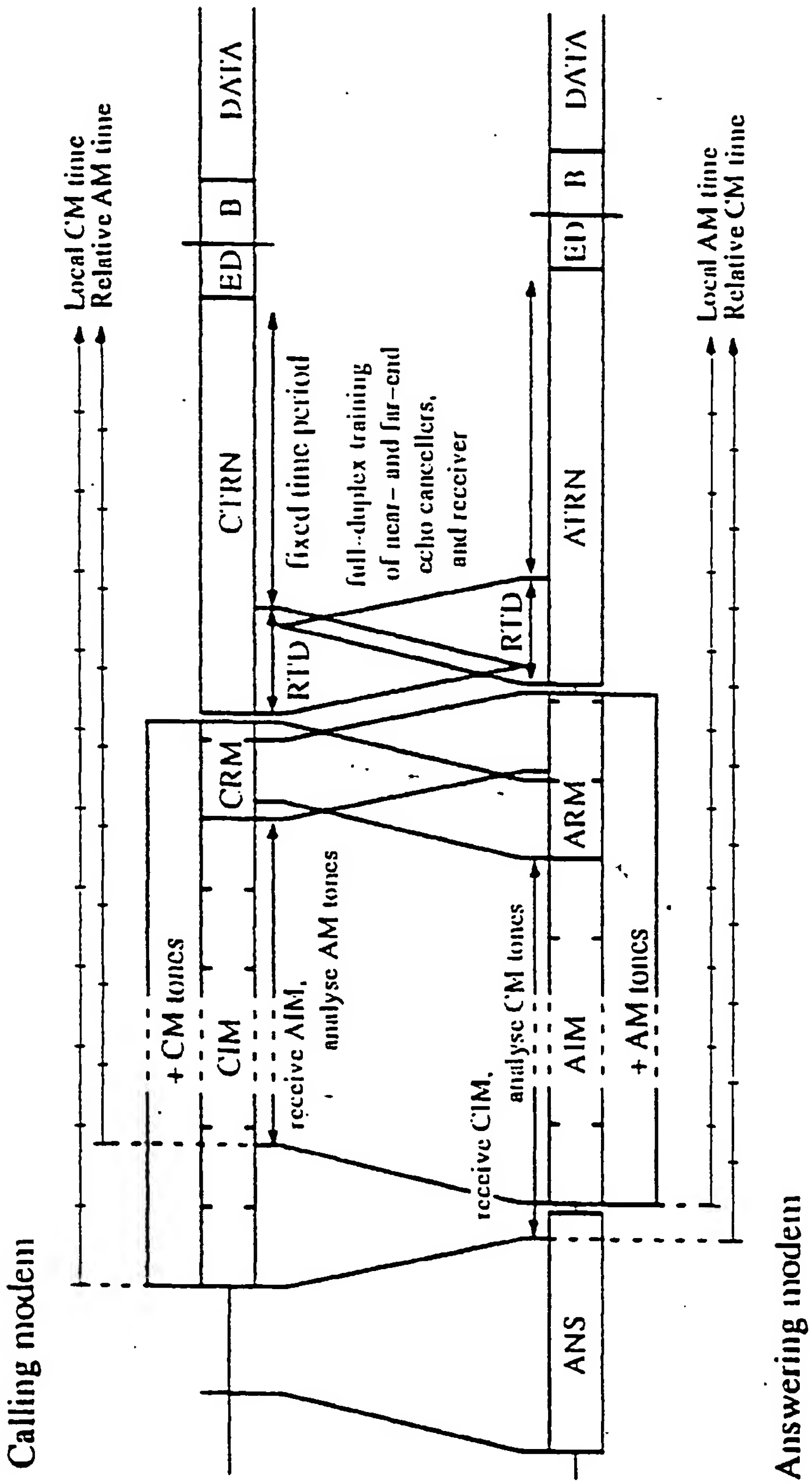
Calling modem
Local CM time
Relative AM time
DATA
B
ED
CTRN
fixed time period
full-duplex training
of near- and far-end
echo cancellers,
and receiver
RTD
RTD
CRM
ARM
CIM
+ CM tones
receive AIM,
analyse AM tones
receive CIM,
analyse CM tones
AIM
+ AM tones
ANS
ATRN
ED
B
DATA
Local AM time
Relative CM time
Answering modem

Figure 1.

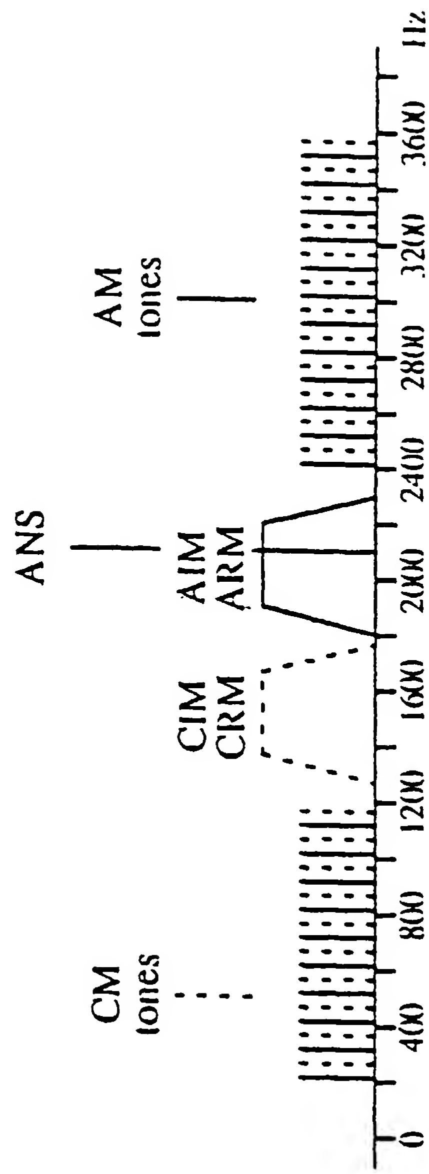
CM
tones
CIM
CRM
ANS
AIM
ARM
AM
tones
0
400
800
1200
1600
2000
2400
2800
3200
3600
Hz

Figure 2.

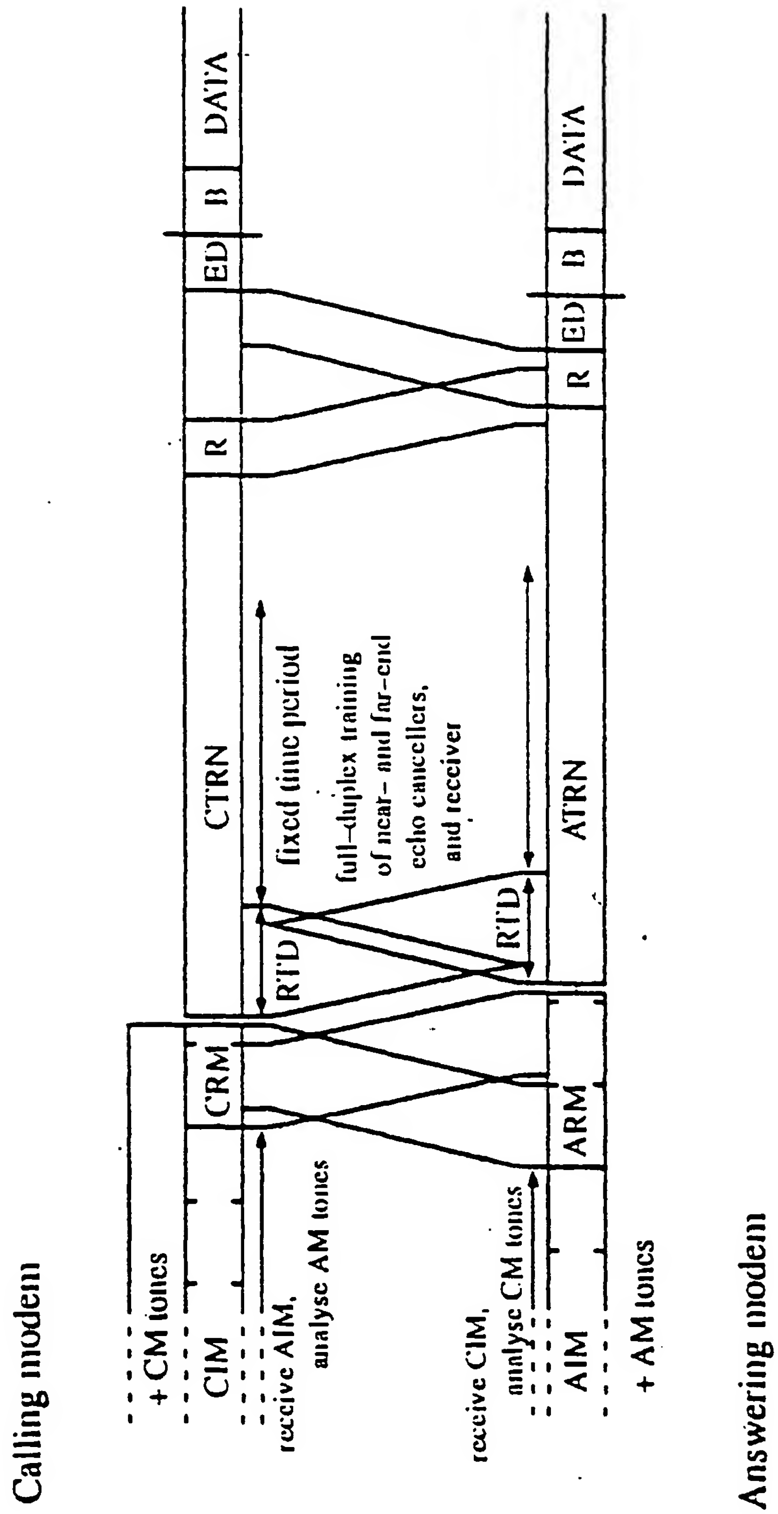
Calling modem
+ CM tones
CIM
receive AIM,
analyse AM tones
CRM
RTD
fixed time period
full-duplex training
of near- and far-end
echo cancellers,
and receiver
CTRN
R
ED
B
DATA
RTD
receive CIM,
analyse CM tones
AIM
+ AM tones
ARM
ATRN
R
ED
B
DATA
Answering modem

Figure 3.